PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION See Form PCT/IPEA/416	
69521-74519		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/SE2004/000607	21-04-2004	22-04-2003
International Patent Classification (IPC) or national classification and IPC		
G01D5/347		
Applicant		
Trimble AB et al		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *(sent to the applicant and to the International Bureau)* a total of 6 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s))
      _____, containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:
   - ☒ Box No. I Basis of the report
   - ☐ Box No. II Priority
   - ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - ☐ Box No. IV Lack of unity of invention
   - ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - ☐ Box No. VI Certain documents cited
   - ☐ Box No. VII Certain defects in the international application
   - ☐ Box No. VIII Certain observations on the international application

Date of submission of the demand	Date of completion of this report
21-02-2005	02-09-2005
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Form PCT/IPEA/409 (cover sheet) (April 2005)

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/SE2004/000607

Box No. I Basis of the report

1. With regard to the **language**, this report is based on:

☒ the international application in the language in which it was filed

☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of:

- ☐ international search (Rules 12.3(a) and 23.1(b))
- ☐ publication of the international application (Rule 12.4(a))
- ☐ international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

☐ the international application as originally filed/furnished

☒ the description:

pages 1-20 as originally filed/furnished
pages* _____ received by this Authority on _____
pages* _____ received by this Authority on _____

☒ the claims:

pages _____ as originally filed/furnished
pages* _____ as amended (together with any statement) under Article 19
pages* 21-26 received by this Authority on 12-07-2005
pages* _____ received by this Authority on _____

☒ the drawings:

pages 1-7 as originally filed/furnished
pages* _____ received by this Authority on _____
pages* _____ received by this Authority on _____

☐ a sequence listing and/or any related table(s) – see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheets/figs _____
- ☐ the sequence listing *(specify)*: _____
- ☐ any table(s) related to the sequence listing *(specify)*: _____

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheets/figs _____
- ☐ the sequence listing *(specify)*: _____
- ☐ any table(s) related to the sequence listing *(specify)*: _____

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/SE2004/000607

Box No. V **Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-27	YES
	Claims		NO
Inventive step (IS)	Claims	1-27	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-27	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

The most relevant documents cited in the International Search Report:

D1: US6333511
D2: EP0765039
D3: JP2000234941

The single general inventive concept of claims 1, 12 and 21 is to achieve high resolution and reduced sensitivity to scale or disk mounting errors in an absolute optical rotary encoder. The problem is solved by using a CCD, reading two code tracks and subsequently from the image selecting a suitable line such that the period length of the imaged pattern of the code tracks matches the period length used in the position calculation.

D1 discloses a method and an apparatus for position determination. The problem solved is to eliminate errors emanating from positional displacement conditions such as optical, mechanical or electronic variation (column 13, lines 38-60). In one embodiment two or more tracks are detected by means of a two-dimensional CCD-matrix (column 2, lines 30-56 and figures 15-17). The pattern is detected in the x- and y-direction. The tracks may have absolute or incremental information (column 11, lines 25-34).

D2 describes a known technique for a rotary encoder suitable for angle measurement. The encoder has two tracks, one absolute and one incremental (page 2, lines 14-23, figure 7).

.../...

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of: Box V

The document discloses sensors at different locations along the periphery (figure 8), and the use of a CCD-linematrix. The device may be used in a surveying instrument.

D3 discloses an absolute position device. The device reads two code tracks, one absolute and one incremental. The detector has two rows of optical grating and a number of columns. The information is extracted from one line of the matrix for each track.

In D1, considered to be closest in describing the invention claimed, there is no teaching given regarding the information from each track being read from one line of the matrix and the way of selecting suitable lines.

The invention claimed is not known from the cited documents or any combination of them. Accordingly, it is new and fulfils the requirement of inventive step.

The invention is industrially applicable.

10/554027
PCT/SE2004/000607
12-07-2005

Claims

1. An absolute position rotary encoding apparatus comprising:

a disk (100) having a first code track and a second code track formed thereon said disk;

a light source (110,111) for illuminating said code tracks;

an area array sensor (115,116) configured to receive the light illuminating said code tracks for imaging a portion of said first and second code tracks simultaneously, said area array sensor capable of imaging onto a pixel matrix having a plurality of rows;

means for reading a first detector line (410) corresponding to a row in the pixel matrix comprising the first code track,

means for reading a second detector line (420) corresponding to a row in the pixel matrix comprising the second code track;

means for compensating for fluctuations in the code track resulting from the disk being inaccurately mounted by selecting a suitable line imaged by the area array sensor such that the period length of the imaged pattern of the code tracks matches the period length used in the position calculation; and

processing means for numerically calculating an absolute position based on the imaged code tracks from the disk.

2. An encoding apparatus according to claim 1, wherein the scale element is an optical disk suitable for use in a rotary encoder and the first code track represents the incremental track and the second code track represents the absolute track.

3. An encoding apparatus according to claim 1, wherein said light source is a photoemitter such as an LED, laser diode, or incandescent light source.

4. An encoding apparatus according to claim 1, wherein the area array sensor is constructed of either CCD or CMOS photodiode technology.

5. An encoding apparatus according to claim 1, wherein said light source and said area array sensor are proximally located on a first side of the scale element and a mirror located on a second side, whereby the emitted light is reflected by the mirror through the scale element to illuminate the code tracks for reception by the sensor.

6. An encoding apparatus according to claim 1, wherein the processing means further includes a Field Programmable Gate Array (FPGA) logic circuit for numerically calculating the phase intensity distribution, the spatial frequency and the phase angle of the image of the code tracks.

7. An encoding apparatus according to claim 1, wherein at least two area array sensors are positioned 180 degrees apart such that the incremental and absolute code tracks are read at two different locations resulting in two different angular positions, and wherein the absolute position is based on the mean of the angular positions.

8. An encoding apparatus according to claim 2, wherein the incremental track is comprised of a plurality of equally spaced and radially distributed markings near the outer edge of the disk, and wherein the absolute track is comprised of markings that form a series of coded lines that include broad and narrow lines radially distributed inside the incremental track such that the broad lines divide the track into equally sized sections and within each section are two narrow data lines that carry information about absolute position.

9. An encoding apparatus according to claim 1, wherein the means for compensating include means for dynamically changing the detector line of the incremental track image, when the pattern period changes due to inaccurate mounting of the scale element which causes undesirable spatial movement of the code track, the detector line is shifted so that it always includes an image with the same pattern period.

10. An encoding apparatus according to claim 1, wherein the means for compensating

include means for altering the numerical value of the pattern period used in the Fourier phase algorithm to match the spatial frequency of fluctuating tracks.

11. An encoding apparatus according to claim 1, wherein four area array sensors are positioned 90 degrees apart such that the incremental and absolute code tracks are read at four different locations.

12. A Total Station theodolite apparatus (700) used for topographic surveying and mapping includes an optical encoder for measuring angular position in the vertical plane and the horizontal plane and cooperates with a servo-mechanism for automatically tracking a target, wherein said encoder comprising:

an optical disk (800,810) having an incremental code track and an absolute code track formed thereon;

a photoemitter light source (110,111) for illuminating the incremental and absolute code tracks;

an area array sensor (115,116) configured to receive the light illuminating said code tracks for imaging a portion of said incremental and absolute code tracks from the disk simultaneously, said area array sensor being capable imaging onto a pixel matrix having a plurality of rows;

means for reading a first detector line (410) corresponding to a row in the pixel matrix comprising the incremental track,

means for reading a second detector line (420) corresponding to a row in the pixel matrix comprising the absolute code track;

means for compensating for a shifting code track resulting from inaccurate mounting of the disk by selecting a suitable line imaged by the area array sensor such that the period length of the imaged pattern of the code tracks matches the period length used in the position calculation;

processing means for calculating an absolute position based on the imaged code tracks from the disk; and

means for calculating the topographic data and tracking information about the target.

13. A Total Station apparatus according to claim 12, wherein the optical disk opaque with transparent code track markings or a transparent disk with opaque code track markings.

14. A Total Station apparatus according to claim 12, wherein the photoemitter is an LED, laser diode, or incandescent light source and the area array sensor is an Interline Transfer (ILT) CCD area array sensor.

15. A Total Station apparatus according to claim 12, wherein the processing means further includes a Field Programmable Gate Array (FPGA) logic circuit for numerically calculating the phase intensity distribution, the spatial frequency and the phase angle of the image of the code tracks.

16. A Total Station apparatus according to claim 12, wherein at least two area array sensors are positioned 180 degrees apart such that the incremental and absolute code tracks are read at two different locations resulting in two different angular positions, and wherein the absolute position is based on the mean of the angular positions.

17. A Total Station apparatus according to claim 12, wherein the incremental track is comprised of a plurality of equally spaced and radially distributed markings near the outer edge of the disk, and wherein the absolute track is comprised of markings that form a series of coded lines that include broad and narrow lines radially distributed inside the incremental track such that the broad lines divide the track into equally sized sections and within each section are two narrow data lines that carry information about absolute position.

18. A Total Station apparatus according to claim 12, wherein the calculating means is performed by a processor and a controller for operating the automatic tracking servo-mechanism.

19. A Total Station apparatus according to claim 12, wherein the means for

compensating include means for dynamically changing the detector line of the incremental track image, when the pattern period changes due to spatial movement of the disk, the detector line is shifted so that it always includes an image with the same pattern period.

20. A Total Station apparatus according to claim 12, wherein the means for compensating include means for altering the numerical value of the pattern period used in the Fourier phase algorithm to match the spatial frequency of fluctuating tracks.

21. A method of calculating an absolute position with an optical rotary encoder device comprising the steps of:

illuminating with a light source ((110,111) an incremental code track and an absolute code track formed on a disk (100);

imaging a segment of the incremental and absolute code tracks onto a CCD or CMOS area array sensor (115,116) wherein the segment is imaged onto a pixel matrix having a plurality of rows;

reading a first detector line (410) corresponding to a row in the matrix comprising the incremental code track;

reading a second detector line (420) corresponding to a row in the matrix comprising the absolute code track;

compensating for fluctuations in the code tracks resulting from inaccurate mounting of the disk by selecting a suitable line imaged by the area array sensor such that the period length of the imaged pattern of the code tracks matches the period length used in the position calculation; and

calculating numerically the absolute position based on the light distribution of the images of the incremental and absolute code tracks.

22. The method according to claim 21, wherein at least two area array sensors are positioned 180 degrees apart such that the incremental and absolute code tracks are read at two different locations resulting in two different angular positions, and wherein the absolute position is based on the mean of the angular positions.

23. The method according to claim 21, wherein said light source and said area array sensor are proximally located on a one side of the scale element and a mirror located on the other side, whereby the emitted light is reflected by the mirror through the scale element to illuminate the code tracks for reception by the sensor.

24. The method according to claim 21, wherein the compensating step dynamically changes the detector line of the incremental track image when the pattern period changes due to spatial movement of the disk, the detector line is shifted so that it always includes an image with the same pattern period.

25. The method according to claim 21, wherein the compensating step includes altering the numerical value of the pattern period used in the Fourier phase algorithm to match the spatial frequency of fluctuating tracks.

26. The method according to claim 21, wherein at least a Field Programmable Gate Array (FPGA) performs at least a portion of the numerical calculations.

27. The method according to claim 21, wherein four area array sensors are positioned 90 degrees apart such that the incremental and absolute code tracks are read at four different locations.